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END POINT DETECTION METHOD IN SEMICONDUCTOR DEVICE ETCHING  
[HANDOTAI SOCHI NO ETCHING NI OKERU SHUTEN KENSHUTSU HOHO]

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[Claims]

1. An end point detection method in etching semiconductor device to detect an end point of etching upon etching in production of a semiconductor device, said method comprising:

forming under a film to be formed on a semiconductor substrate and to be etched a film made of a material that emits light at different wavelength from that of a film to be etched; and

detecting an end point of etching the film to be etched by measuring light emission from the film.

2. The end point detection method in etching a semiconductor device according to Claim 1, wherein the film that emits light at different wavelength from that of the film to be etched is a fluorocarbon film.

[Detailed Description of the Invention]

[0001]

[Applicable Industrial Field]

The present invention relates to an end point detection method used upon etching in semiconductor device production, especially upon reactive ion etching (O<sub>2</sub> RIE) of an organic material, which is used in multilayer resist lithography.

[0002]

[Prior Art]

While there have been conventionally various methods for detecting an end point upon etching in production of a semiconductor device, emission spectroscopy has been frequently employed since it is superior in view of reliability and cost efficiency. This fact is described in, for example, Takuo Sugano, "Handotai Plasma Process Gijutsu (Semiconductor Plasma Process Technology)" 1<sup>st</sup> Ed., 2<sup>nd</sup> Print (June 27, 1982), Sangyo Tosho, pp. 111-116.

[0003]

As also described in the literature, emission spectroscopy is a method to measure emitted light according to energy levels of atoms, molecules, and ions in plasma.

[0004]

Hereunder, outline of the present invention will be described referring to etching of a polysilicon film (hereinafter referred to as "Poly-Si") formed on a semiconductor substrate as an example.

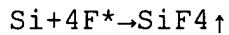
[0005]

Fig. 4 shows emission intensity change in an example of monitoring etching of a Poly-Si using Freon gas. The monitoring was conducted under conditions of film thickness of 3,500 Å,  $\text{CF}_4 + \text{O}_2$  (5 %) gas, pressure of 0.35 Torr, and RF

power of 150 W using a filter for measurement wavelength of 704 nm.

[0006]

In this process, the Poly-Si is etched as expressed in the following reaction formula:



More specifically, since  $\text{F}^*$  (fluorine radical) reacts with Si (silicon) once the reaction starts, the emission intensity (spectrum intensity) of  $\text{F}^*$  decreases. Then, once it is close to completion (an end point of the Poly-Si etching), it becomes more intense and then saturated upon completion since no reaction with Si does not occur anymore. Using this phenomenon, an end point of the Poly-Si etching can be detected by measuring emission intensity (emission intensity at 704 nm in this example) from  $\text{F}^*$ .

[0007]

[Problems to be Solved by the Invention]

However, the above-described end point detection method has the following drawbacks.

[0008]

(1) If a substrate under a film to be etched has an uneven surface (See Fig. 1) or the etching speed is not even in a wafer (semiconductor substrate) surface, since the end point of etching cannot be clearly determined, the emission

(spectrum) intensity change becomes mild and it becomes difficult to precisely detect the end point.

[0009]

(2) While detection of an etching end point is originally to know a time point when a part of the substrate is exposed (i.e. beginning of the end point), it is difficult to detect such time point because of small emission intensity change.

[0010]

Any of the above drawbacks are caused by that end points, removal of the etched film portions, do not occur at the same time.

[0011]

In order to solve the above problems, there is provided an invention, an object of which is to provide a method, in which a structure related to a film to be etched is improved and thereby precise detection of an end point is enabled.

[0012]

[Means to Solve the Problems]

In order to achieve the above objects, according to the present invention, a film, which emits light of significantly different wavelength from that of the film to be etched but has similar etching properties to those of

the film to be etched (e.g. fluorocarbon film), is formed and an end point can be detected by detecting a time point of the light emission.

[0013]

[Working Principle of the Invention]

As described above, according to this invention, since a film that emits light at different wavelength from that of the film to be etched is formed under the film to be etched, once it is close to the etching end point, the emission intensity suddenly increases from a state of almost no emission intensity from an object for detection, i.e. a film to be etched, the end point can be more easily and more accurately detected.

[0014]

[Embodiment]

Referring now to Fig. 1, a first embodiment will be described below.

[0015]

The first embodiment is an example of detecting an end point of etching a multilayer resist. In other words, a film to etch (a film to be etched) is a resist film.

[0016]

Fig. 2 shows the emission intensity in the etching; and Fig. 3 is a schematic view of a dry etching device to carry out this embodiment.

[0017]

Since the etching device of Fig. 3 is well known one, detailed description will not be necessary. As shown in Fig. 3, in the device, a reaction chamber having electrodes [4] and [5] has a window [2] on the side and an emission spectrometer [1] is provided near the window. As well known, for etching, a wafer is placed on a base (not illustrated) on the cathode [4], gas ( $O_2$ ) is introduced, and the film is etched while generating plasma by applying high-frequency waves (RF). Normally, the spectrum change of the plasma beam in the reaction chamber is introduced in the emission spectrometer [1] and then electrically converted, and thereby the etching state is monitored. In this example, emission intensity from  $F^*$  at 704 nm was measured.

/3

[0018]

As shown in Fig. 1(a), in this embodiment, a about 500 Å fluorocarbon film [6] is first formed on a substrate [5] having uneven surface. This film is formed by plasma CVD using  $CHF_3$  gas. Thereafter, a resist [7] and an  $O_2$  RIE mask

[8] are formed on the fluorocarbon film [6] by a well-known method.

[0019]

The fluorocarbon film [6] has emission peak of  $F^*$  around 700 nm, which is significantly different from an emission peak of normal resist [7] around 480 nm.

[0020]

After forming the film as described above, the substrate [5] is set in the device of Fig. 3 and etching is performed. The etching state is shown in Figs. 1(b) and (c).

[0021]

The etching conditions were  $O_2$  gas flow of 20 sccm, pressure of 10 mTorr, and RF power of 200 W.

[0022]

As described above, since the resist [7] does not have a strong emission peak around 700 nm, the emission is almost 0 (See the portion a-b in Fig. 2) in a state where the fluorocarbon film [6] is not exposed as shown in Fig. 1(b).

[0023]

Once the etching progresses and the fluorocarbon film [6] is exposed as shown in Fig. 1(c), the emission intensity of  $F^*$  around 700 nm, which is generated from the

film [6], suddenly rises (portion c in Fig. 2). Accordingly, by measuring this rise, a start point of the end of etching, i.e. a time point when the resist [7], a film to be etched, is etched and the fluorocarbon film thereunder is exposed, can be extremely easily and accurately detected.

[0024]

Although it is not illustrated, a second embodiment of the invention will be described below. The second embodiment is an example in which the invention is applied in measurement of speed of sputter etching by O<sub>2</sub> RIE. Needless to say, the etching device used herein is the one shown in Fig. 3. Here, in this embodiment, the emission was measured at the wavelength of 483.5 nm since the emission is from CO as will be described.

[0025]

In the second embodiment, as a film to be etched, inorganic film such as SiO<sub>2</sub>, W, or Ti was mainly formed into about 500 Å thickness, and about 2-μm thick photoresist is provided under the film to be etched. In other words, while the thickness of the film is different, the position of the resist is opposite to the one in Fig. 1. More specifically, a photoresist is formed under the film to be etched as a film that emits light at different wavelength,

and the etching speed is measured with the film to be etched such as  $\text{SiO}_2$  or W film.

[0026]

In the measurement, the thickness of the film to be etched, which is used for measurement of the sputter etching speed, is measured in advance.

[0027]

Then,  $\text{O}_2\text{RIE}$  is performed. Once the etching progresses and the resist becomes exposed, the organic film, the resist film, generates CO and the emission is detected. That is, the end point of the etching can be detected. Accordingly, the etching speed can be easily and precisely determined if the time until the end point is detected is measured and the initial film thickness is divided by the  $\text{O}_2$  RIE time required until the light emission from CO is detected.

[0028]

Here, the film to form under the film to be etched may not have to be the fluorocarbon film or the resist used in this embodiment, may be any as long as it is made of a material that conveniently emits light for the end point detection. For example, similar effects can be achieved even by fluorocarbon. [Translator's Note: The underlined

parts are translated as is described in the source document.]

[0029]

[Effects of the Invention]

As described above, according to the invention, since a film that emits light at different wavelength from that of a film to be etched is formed the film to be etched, the end point of etching can be easily and precisely detected, and the production efficiency of a semiconductor device can be improved and the quality reliability can be enhanced.

[Brief Description of the Drawings]

Fig. 1 is an explanatory view of an embodiment of the invention.

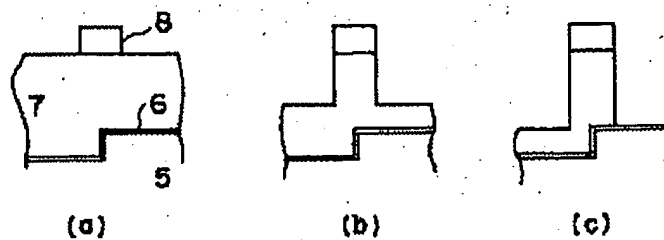
Fig. 2 shows emission intensity change at 704 nm in O<sub>2</sub> RIE.

Fig. 3 is a reactive ion etching device to carry out the invention.

Fig. 4 is an example of emission intensity change of Poly-Si.

[Description of Reference Numerals]

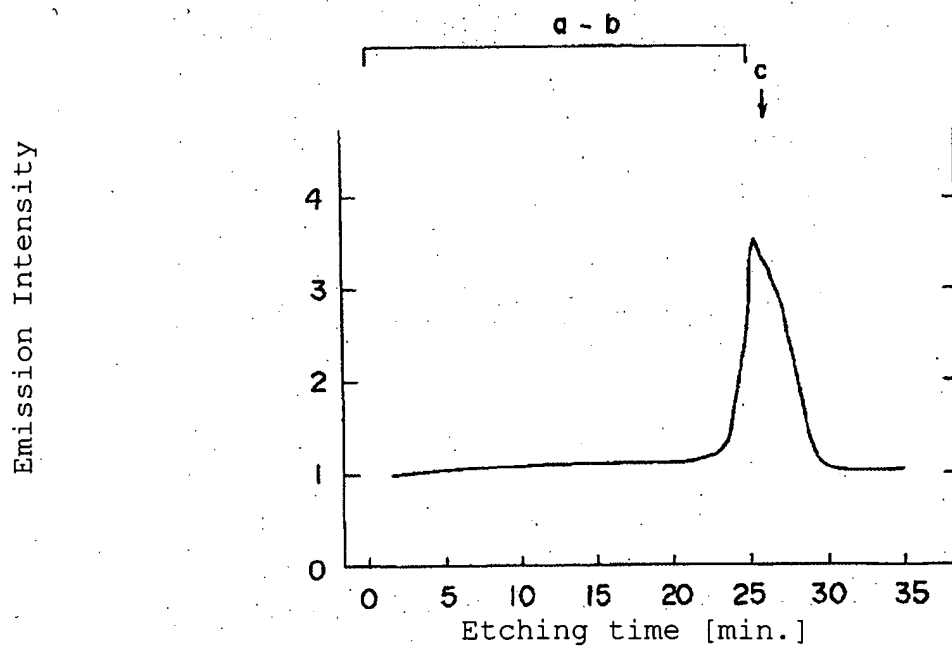
- 5: Substrate
- 6: Fluorocarbon film
- 7: Resist
- 8: O<sub>2</sub> RIE mask



Explanatory view of an embodiment of the invention

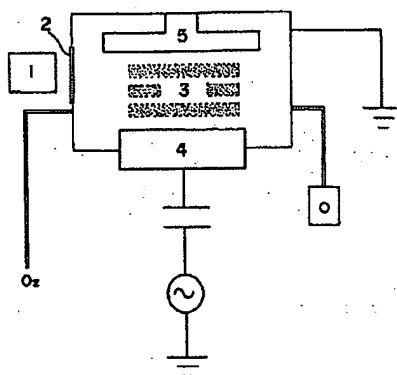
- 5: Substrate
- 6: Fluorocarbon film
- 7: Resist
- 8: O<sub>2</sub> RIE mask

[Fig. 1]



Emission Intensity Change at 704 nm in O<sub>2</sub> RIE

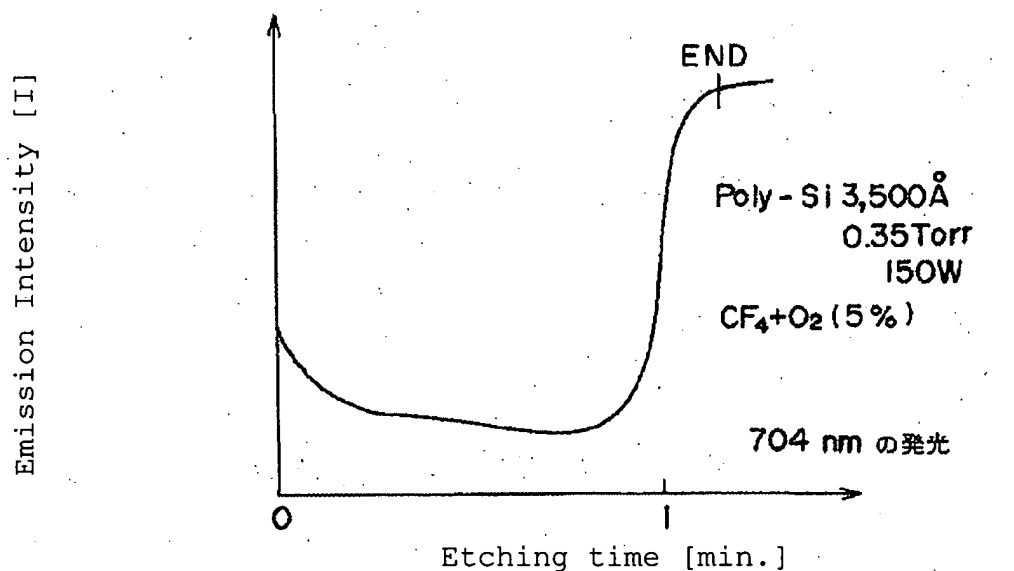
[Fig. 2]



Reactive Ion Etching Device to Carry out the Invention

- 1: Emission spectrometer
- 2: Window
- 3: Plasma
- 4: Cathode
- 5: Upper electrode

[Fig. 3]



Example of Emission Intensity Change of Poly-Si  
[Fig. 4]